

The New Ways and the Old Ways of How to View* Scintillation

*in the metaphorical sense, not the
photon detection sense!

The Work Function

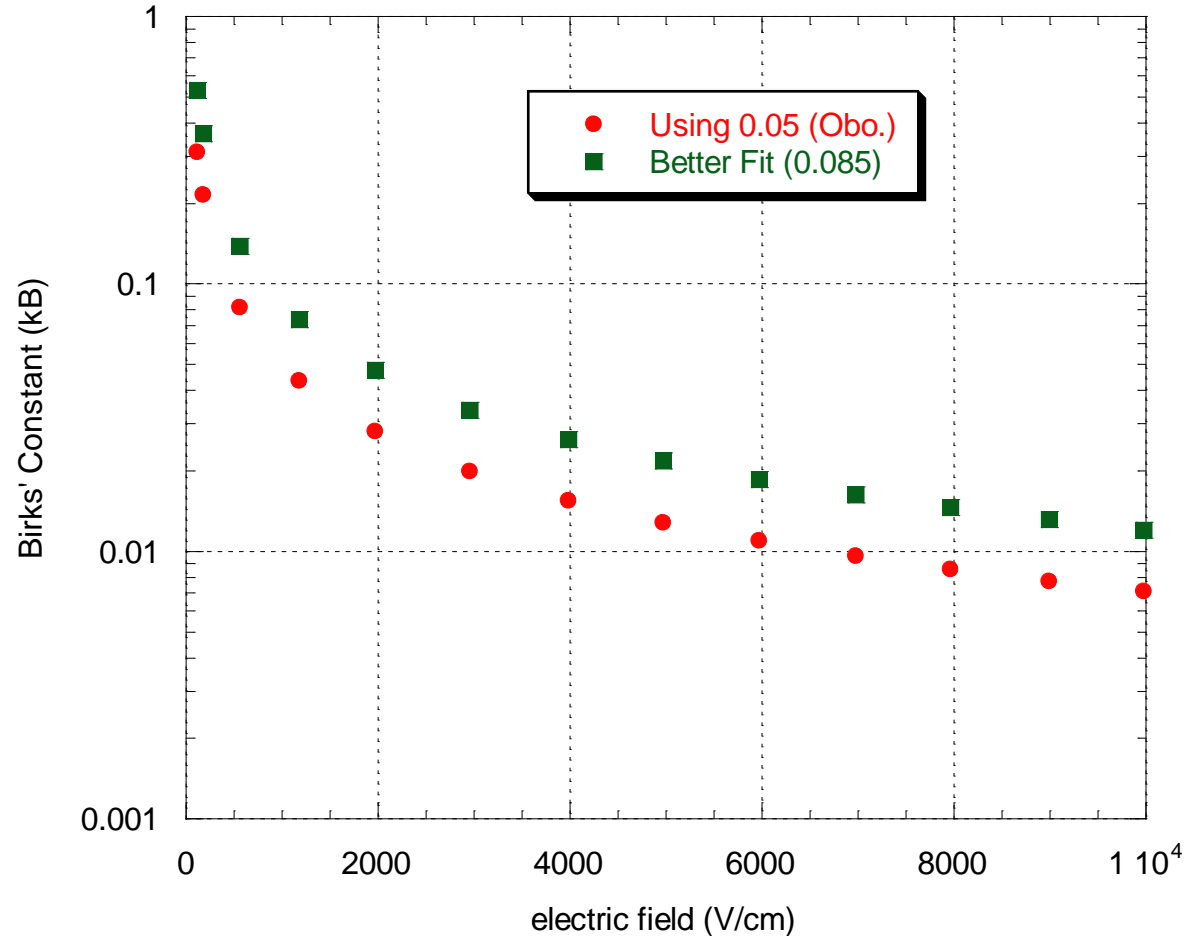
- From Craig Thorn's LAr summary document: **W = 19.5 eV** for scintillation and **23.6 eV** for ionization
- NEST unifies these two processes into just one work function
- $W_{\text{scint}} = E / (N_{\text{ex}} + N_i) = 19.5 \text{ eV}$ (complete recombination)
- $W_{\text{ion}} = E / N_i = (E/N_i) * (N_{\text{ex}} + N_i) / (N_{\text{ex}} + N_i) = (N_{\text{ex}} + N_i) / N_i * E / (N_{\text{ex}} + N_i) = (N_{\text{ex}} / N_i + 1) * E / (N_{\text{ex}} + N_i) = 1.21 * \mathbf{19.5} = \mathbf{23.6 \text{ eV}}$ (complete non-recombination, at infinite field)
- Answers Tom Junk's question of why combine into one W?
- This is not just numerology: it works, and it's not my own idea: See the Ph.D. Thesis of Eric Dahl (Princeton, 2009). I'm sure that others have thought of this as well...
- dE/dx dependences goes into the recombination probability, and not the work function: at low LET no "quenching," just different amount of recombination

The dE/dx Dependence

- NEST takes the Birks' Law for yield and converts it into the recombination probability
- $dL/dE = A*(dE/dx)/(1+B*dE/dx)$ becomes
- $r = A*(dE/dx)/(1+A*dE/dx)$, which goes from 0 -1 (if $A = B$)
- And then, $N_{ph} = N_{ex} + r * N_i$ and $N_e = (1 - r) * N_i$
- dQ/dE can be thought of as escape probability. Let's derive the Obodovski formula, used also in LArSoft...
- $1 - r = 1 - A*(dE/dx)/(1+A*dE/dx) = (1+A*dE/dx) / (1+A*dE/dx) - A*(dE/dx)/(1+A*dE/dx) = 1 / (1+A*dE/dx)$, which is the same as Obodovski's formula, up to a normalization
- But now the question is how does this A (or k_B) vary with electric field: at least two possible models: power law, or constant divided by field (these are almost the same)

Comparison to Data

- Obodovski has a literature-averaged formula of $k_B = 0.05 * F^{-0.85}$, where F is the field (kV/cm)
- The 1 MeV data I showed from Doke 2002 at the collaboration meeting fits better with a different amplitude, but the shape, driven by the exponent, looks great!
- Issue: at high LET, using this formula makes the light yield go above the zero field value I showed, at low fields



Task List

- We need to use the literature and check:
 - Light yield versus energy at a fixed field
 - Charge yield versus energy
 - Light yield versus field at fixed energies
 - Ditto again, for charge yield
 - Corrections for different particle type: quenching at very high LET (HIPs) or maybe we don't care
 - (Drifting electrons: drift velocity and diffusion)
 - Soon it will be appropriate to get volunteers